HW02WP_ML

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0.1 HW 2 Analysis Problems

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0.2 1. Data Wrangling, Pre-Processing I

Import datetime

[ ]:
```
from datetime import datetime as dt
now = dt.now()
print("Analysis on", now.strftime("%Y-%m-%d"), "at", now.strftime("%H:%M %p"))
```

```
Analysis on 2023-07-06 at 11:32 AM
```

Import packages

[ ]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
```

Consider the following csv data file regarding houses and their average selling price in various geographical areas around Boston:

http://web.pdx.edu/~gerbing/data/Boston.csv

There are 14 variables in the data file, described as follows:

1. crim - per capita crime rate by town
2. zn - proportion of residential land zoned for lots over 25,000 sq.ft.
3. indus - proportion of non-retail business acres per town.
4. chas - charles river dummy variable (1 if tract bounds river; 0 otherwise)
5. nox - nitric oxides concentration (parts per 10 million)
6. rm - average number of rooms per dwelling
7. age - proportion of owner-occupied units built prior to 1940
8. dis - weighted distances to five boston employment centers
9. rad - index of accessibility to radial highways
10. tax - full-value property-tax rate per 10,000 USD
11. ptratio - pupil-teacher ratio by town
12. “b - 1000(bk - 0.63)^2” where bk is the proportion of blacks by town
13. lstat - % lower status of the population
14. medv - median value of owner-occupied homes in 1000’s USD

a. Read the data file.

```
[ ]: df = pd.read_csv("http://web.pdx.edu/~gerbing/data/Boston.csv")
     df.head()
```

```
[ ]:    Unnamed: 0     crim    zn  indus  chas    nox     rm   age     dis  rad  \
     0           1  0.00632  18.0   2.31     0  0.538  6.575  65.2  4.0900    1
     1           2  0.02731   0.0   7.07     0  0.469  6.421  78.9  4.9671    2
     2           3  0.02729   0.0   7.07     0  0.469  7.185  61.1  4.9671    2
     3           4  0.03237   0.0   2.18     0  0.458  6.998  45.8  6.0622    3
     4           5  0.06905   0.0   2.18     0  0.458  7.147  54.2  6.0622    3

        tax  ptratio   black  lstat  medv
     0  296     15.3  396.90   4.98  24.0
     1  242     17.8  396.90   9.14  21.6
     2  242     17.8  392.83   4.03  34.7
     3  222     18.7  394.63   2.94  33.4
     4  222     18.7  396.90   5.33  36.2
```

The data frame imported with "unnamed column 0". Removing that column...

```
[ ]: df = df.drop(columns=df.columns[0])
     df
```

```
[ ]:         crim    zn  indus  chas    nox     rm   age     dis  rad  tax  \
     0     0.00632  18.0   2.31     0  0.538  6.575  65.2  4.0900    1  296
     1     0.02731   0.0   7.07     0  0.469  6.421  78.9  4.9671    2  242
     2     0.02729   0.0   7.07     0  0.469  7.185  61.1  4.9671    2  242
     3     0.03237   0.0   2.18     0  0.458  6.998  45.8  6.0622    3  222
     4     0.06905   0.0   2.18     0  0.458  7.147  54.2  6.0622    3  222
     ..        ...   ...    ...   ...    ...    ...   ...     ...  ...  ...
     501   0.06263   0.0  11.93     0  0.573  6.593  69.1  2.4786    1  273
     502   0.04527   0.0  11.93     0  0.573  6.120  76.7  2.2875    1  273
     503   0.06076   0.0  11.93     0  0.573  6.976  91.0  2.1675    1  273
     504   0.10959   0.0  11.93     0  0.573  6.794  89.3  2.3889    1  273
     505   0.04741   0.0  11.93     0  0.573  6.030  80.8  2.5050    1  273

          ptratio   black  lstat  medv
     0       15.3  396.90   4.98  24.0
     1       17.8  396.90   9.14  21.6
     2       17.8  392.83   4.03  34.7
     3       18.7  394.63   2.94  33.4
     4       18.7  396.90   5.33  36.2
     ..       ...     ...    ...   ...
     501     21.0  391.99   9.67  22.4
     502     21.0  396.90   9.08  20.6
     503     21.0  396.90   5.64  23.9
     504     21.0  393.45   6.48  22.0
```

```
505     21.0  396.90   7.88  11.9

[506 rows x 14 columns]
```

b. How many examples (rows of data) are there in the data file?

Check the shape of the data frame

[ ]:
```
df.shape
```

[ ]:
```
(506, 14)
```

c. List the first 5 rows and the variable names.

[ ]:
```
df.head()
```

[ ]:
```
      crim    zn  indus  chas    nox     rm   age     dis  rad  tax  ptratio  \
0  0.00632  18.0   2.31     0  0.538  6.575  65.2  4.0900    1  296     15.3
1  0.02731   0.0   7.07     0  0.469  6.421  78.9  4.9671    2  242     17.8
2  0.02729   0.0   7.07     0  0.469  7.185  61.1  4.9671    2  242     17.8
3  0.03237   0.0   2.18     0  0.458  6.998  45.8  6.0622    3  222     18.7
4  0.06905   0.0   2.18     0  0.458  7.147  54.2  6.0622    3  222     18.7

    black  lstat  medv
0  396.90   4.98  24.0
1  396.90   9.14  21.6
2  392.83   4.03  34.7
3  394.63   2.94  33.4
4  396.90   5.33  36.2
```

d. Transform lstat *from a percentage to a proportion. Do this by writing the usual equation for this transformation in the language of Pandas, perhaps first writing the expression on paper and then translate to Pandas notation. (Name the new variable anything you wish.) Verify by displaying the first six rows of the revised data frame.*

Divide lstat % by 100 to transform into a proportion

[ ]:
```
df['lstat_prop'] = df['lstat']/100
df.head(6)
```

[ ]:
```
      crim    zn  indus  chas    nox     rm   age     dis  rad  tax  ptratio  \
0  0.00632  18.0   2.31     0  0.538  6.575  65.2  4.0900    1  296     15.3
1  0.02731   0.0   7.07     0  0.469  6.421  78.9  4.9671    2  242     17.8
2  0.02729   0.0   7.07     0  0.469  7.185  61.1  4.9671    2  242     17.8
3  0.03237   0.0   2.18     0  0.458  6.998  45.8  6.0622    3  222     18.7
4  0.06905   0.0   2.18     0  0.458  7.147  54.2  6.0622    3  222     18.7
5  0.02985   0.0   2.18     0  0.458  6.430  58.7  6.0622    3  222     18.7

    black  lstat  medv  lstat_prop
0  396.90   4.98  24.0      0.0498
```

```
1  396.90   9.14  21.6      0.0914
2  392.83   4.03  34.7      0.0403
3  394.63   2.94  33.4      0.0294
4  396.90   5.33  36.2      0.0533
5  394.12   5.21  28.7      0.0521
```

e. Display just the average number of rooms for the second row of data.

Use iloc to find the single value from row 2 of 'rm' column.

[ ]:
```
df['rm'].iloc[1:2]
```

[ ]:
```
1    6.421
Name: rm, dtype: float64
```

f. To build a model to forecast median house price, analysts wish to focus on three predictor variables: crim, rm, and rad. Display the first five rows of data for just these three variables.
i. by specifying the variable names
ii. by specifying the variable indices

Filter the first five rows of crim, rm, and rad using filter().

[ ]:
```
df2 = df.filter(['crim', 'rm', 'rad'])
df2.head()
```

[ ]:
```
      crim     rm  rad
0  0.00632  6.575    1
1  0.02731  6.421    2
2  0.02729  7.185    2
3  0.03237  6.998    3
4  0.06905  7.147    3
```

Same thing using loc()

[ ]:
```
df2 = df.loc[:, ['crim', 'rm', 'rad']]
df2.head()
```

[ ]:
```
      crim     rm  rad
0  0.00632  6.575    1
1  0.02731  6.421    2
2  0.02729  7.185    2
3  0.03237  6.998    3
4  0.06905  7.147    3
```

Filter the first five rows of crim, rm, and rad by specifying the variable indices

[ ]:
```
df2 = df.iloc[:, [0, 5, 8]]
df2.head()
```

[ ]:

	crim	rm	rad
0	0.00632	6.575	1
1	0.02731	6.421	2
2	0.02729	7.185	2
3	0.03237	6.998	3
4	0.06905	7.147	3

g. List all the rows of data with the median value of the home less than $8000.

Filter all values in medv column less than 8 (in 1000s)

[ ]:
```
df.query('medv < 8')
```

[ ]:

	crim	zn	indus	chas	nox	rm	age	dis	rad	tax	\
385	16.81180	0.0	18.10	0	0.700	5.277	98.1	1.4261	24	666	
387	22.59710	0.0	18.10	0	0.700	5.000	89.5	1.5184	24	666	
398	38.35180	0.0	18.10	0	0.693	5.453	100.0	1.4896	24	666	
399	9.91655	0.0	18.10	0	0.693	5.852	77.8	1.5004	24	666	
400	25.04610	0.0	18.10	0	0.693	5.987	100.0	1.5888	24	666	
401	14.23620	0.0	18.10	0	0.693	6.343	100.0	1.5741	24	666	
405	67.92080	0.0	18.10	0	0.693	5.683	100.0	1.4254	24	666	
414	45.74610	0.0	18.10	0	0.693	4.519	100.0	1.6582	24	666	
415	18.08460	0.0	18.10	0	0.679	6.434	100.0	1.8347	24	666	
416	10.83420	0.0	18.10	0	0.679	6.782	90.8	1.8195	24	666	
489	0.18337	0.0	27.74	0	0.609	5.414	98.3	1.7554	4	711	

	ptratio	black	lstat	medv	lstat_prop
385	20.2	396.90	30.81	7.2	0.3081
387	20.2	396.90	31.99	7.4	0.3199
398	20.2	396.90	30.59	5.0	0.3059
399	20.2	338.16	29.97	6.3	0.2997
400	20.2	396.90	26.77	5.6	0.2677
401	20.2	396.90	20.32	7.2	0.2032
405	20.2	384.97	22.98	5.0	0.2298
414	20.2	88.27	36.98	7.0	0.3698
415	20.2	27.25	29.05	7.2	0.2905
416	20.2	21.57	25.79	7.5	0.2579
489	20.1	344.05	23.97	7.0	0.2397

h. Use code (i.e., do not manually count) to display the number of homes with median value < $8000.

Count the number of homes with median value < 8

[ ]:
```
homes = df.query('medv < 8')['medv'].count()
print("Number of homes with medv < $8000: ", (homes))
```

```
Number of homes with medv < $8000:  11
```

i. Analysts want to build a model to forecast the median value of a house. Construct the box plot

of the corresponding variable medv.

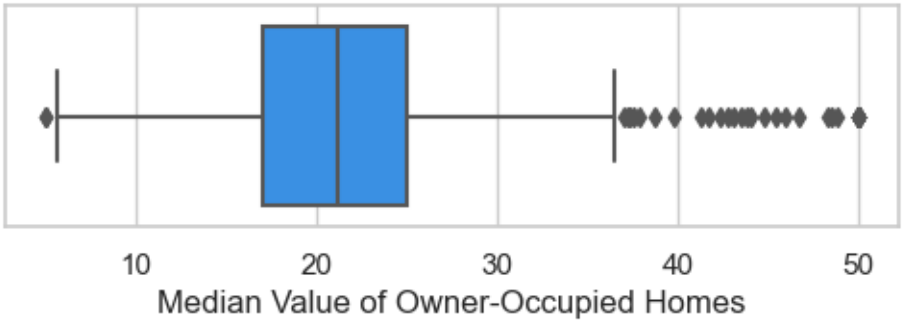
```
# Set plot theme
sns.set_theme(style='whitegrid')

# Use seaborn to create boxplot for the variable medv
plot = sns.boxplot(x=df['medv'], color='dodgerblue')

# Resize the figure
sns.set(rc={'figure.figsize': (6, 1.5)})

# Addd axis label
plot.set(xlabel='Median Value of Owner-Occupied Homes')
```

```
[Text(0.5, 0, 'Median Value of Owner-Occupied Homes')]
```



j. Describe the distribution of medv from the box plot including any outliers.

The data within the medv column is highly dispersed, with a range from 5-50. The mean is 22.53 and the median is 21.2. The middle 50% of values lie between 17 and 25, and the standard deviation is just over 9. There are a number of potential outliers with high values that skew the data to the right, and there is at least one potential outlier at the bottom end of the range.

```
round(df.describe()['medv'], 2)
```

```
count    506.00
mean      22.53
std        9.20
min        5.00
25%       17.02
50%       21.20
75%       25.00
max       50.00
Name: medv, dtype: float64
```

k. For the three predictor variables of interest, rescale into a data object called X three ways, each

time showing the first five rows of rescaled data.
i. MinMax, and also show the minimum and maximum of the rescaled variables
ii. Standardize, and also show the mean and standard deviation of the rescaled variables and comment on their respective sizes
iii. Robust Scale

Pre-processing Import sklearn preprocessing module

[ ]:
```
from sklearn import preprocessing
```

View data types of predictor variables.

[ ]:
```
df[['crim', 'rm', 'rad']].dtypes
```

[ ]:
```
crim    float64
rm      float64
rad       int64
dtype: object
```

Subset the predictor variables (crim, rm, & rad) into their own data frame and update 'rad' to float64

[ ]:
```
X = df[['crim', 'rm', 'rad']].copy()
X.loc[:, 'rad'] = X.loc[:, 'rad'].astype('Float64')
X.head()
```

[ ]:

	crim	rm	rad
0	0.00632	6.575	1.0
1	0.02731	6.421	2.0
2	0.02729	7.185	2.0
3	0.03237	6.998	3.0
4	0.06905	7.147	3.0

i. Scale using MinMax Import MinMax Scaler and create mm_scaler instance

[ ]:
```
from sklearn.preprocessing import MinMaxScaler
mm_scaler = preprocessing.MinMaxScaler()
```

Transform X using MinMaxScaler and view object type

[ ]:
```
Xmm = mm_scaler.fit_transform(X)
type(Xmm)
```

[ ]:
```
numpy.ndarray
```

Transform Xmm into a data frame and view first 5 rows

[ ]:
```
Xmm = pd.DataFrame(Xmm, columns=['crim', 'rm', 'rad'])
Xmm.head()
```

[ ]:

	crim	rm	rad
0	0.000000	0.577505	0.000000
1	0.000236	0.547998	0.043478
2	0.000236	0.694386	0.043478
3	0.000293	0.658555	0.086957
4	0.000705	0.687105	0.086957

View Min values

[ ]:
```
Xmm.min()
```

[ ]:
```
crim    0.0
rm      0.0
rad     0.0
dtype: float64
```

View Max values

[ ]:
```
Xmm.max()
```

[ ]:
```
crim    1.0
rm      1.0
rad     1.0
dtype: float64
```

ii. Scale using Standardization Import StandardScaler module and create instance

[ ]:
```
from sklearn.preprocessing import StandardScaler
s_scaler = preprocessing.StandardScaler()
```

Transform using Standard Scaler and convert back to data frame

[ ]:
```
Xst = s_scaler.fit_transform(X)
Xst = pd.DataFrame(Xst, columns=['crim', 'rm', 'rad'])
Xst.head()
```

[ ]:

	crim	rm	rad
0	-0.419782	0.413672	-0.982843
1	-0.417339	0.194274	-0.867883
2	-0.417342	1.282714	-0.867883
3	-0.416750	1.016303	-0.752922
4	-0.412482	1.228577	-0.752922

View the mean

[ ]:
```
round(Xst.mean(), 4)
```

[ ]:
```
crim   -0.0
rm     -0.0
rad    -0.0
```

```
dtype: float64
```

View standard deviation

[ ]:
```
round(Xst.std(), 4)
```

[ ]:
```
crim    1.001
rm      1.001
rad     1.001
dtype: float64
```

The mean of 0 and standard deviation of 1 represents a normal distribution of data. This ensures that the distribution of the data points is similar across different variables.

iii. Robust Scale Import RobustScaler module and create instance

[ ]:
```
from sklearn.preprocessing import RobustScaler
r_scaler = preprocessing.RobustScaler()
```

Transform X using RobustScaler and convert back to data frame

[ ]:
```
Xrb = r_scaler.fit_transform(X)
Xrb = pd.DataFrame(Xrb, columns=['crim', 'rm', 'rad'])
Xrb.head()
```

[ ]:
```
       crim        rm   rad
0 -0.069593  0.496612 -0.20
1 -0.063755  0.287940 -0.15
2 -0.063760  1.323171 -0.15
3 -0.062347  1.069783 -0.10
4 -0.052144  1.271680 -0.10
```

View the mean

[ ]:
```
round(Xrb.mean(), 4)
```

[ ]:
```
crim    0.9338
rm      0.1032
rad     0.2275
dtype: float64
```

View the standard deviation

[ ]:
```
round(Xrb.std(), 4)
```

[ ]:
```
crim    2.3926
rm      0.9521
rad     0.4354
dtype: float64
```

View min

[ ]:
```
round(Xrb.min(), 4)
```

[ ]:
```
crim   -0.0696
rm     -3.5874
rad    -0.2000
dtype: float64
```

View max

[ ]:
```
round(Xrb.max(), 4)
```

[ ]:
```
crim    24.6784
rm       3.4844
rad      0.9500
dtype: float64
```

0.3 2. Data Wrangling, Pre-Processing II

Data: http://web.pdx.edu/~gerbing/data/SupermarketTransactions.xlsx (sample data from Tableau)

Read in the data

[ ]:
```
supermarket = pd.read_excel('http://web.pdx.edu/~gerbing/data/
  ↪SupermarketTransactions.xlsx')
supermarket.head()
```

[ ]:
```
   Transaction   Purchase  Customer Gender Marital Homeowner  Children  \
0            1 2015-12-17      7223      F       S         Y         2
1            2 2015-12-19      7841      M       M         Y         5
2            3 2015-12-20      8374      F       M         N         2
3            4 2015-12-20      9619      M       M         Y         3
4            5 2015-12-21      1900      F       S         Y         3

          Income           City State Country Family         Dept  \
0    $30K - $50K    Los Angeles    CA     USA   Food  Snack Foods
1    $70K - $90K    Los Angeles    CA     USA   Food      Produce
2    $50K - $70K      Bremerton    WA     USA   Food  Snack Foods
3    $30K - $50K       Portland    OR     USA   Food       Snacks
4  $130K - $150K  Beverly Hills    CA     USA  Drink    Beverages

               Category  Units_Sold  Revenue
0           Snack Foods           5    27.38
1            Vegetables           5    14.90
2           Snack Foods           3     5.52
3                 Candy           4     4.44
4  Carbonated Beverages           4    14.00
```

a. *How many examples, rows of data? Columns of data?*

View the shape of the data frame

[ ]:
```
supermarket.shape
```

[ ]:
```
(14059, 16)
```

b. *Convert the value of Country, USA, to USofA. Verify. (Always verify the data after a transformation.)*

Replace USA with USofA targeting the 'Country' column

[ ]:
```
supermarket = supermarket.replace({'Country': {'USA': 'USofA'}})
supermarket.head()
```

[ ]:

	Transaction	Purchase	Customer	Gender	Marital	Homeowner	Children
0	1	2015-12-17	7223	F	S	Y	2
1	2	2015-12-19	7841	M	M	Y	5
2	3	2015-12-20	8374	F	M	N	2
3	4	2015-12-20	9619	M	M	Y	3
4	5	2015-12-21	1900	F	S	Y	3

	Income	City	State	Country	Family	Dept
0	$30K - $50K	Los Angeles	CA	USofA	Food	Snack Foods
1	$70K - $90K	Los Angeles	CA	USofA	Food	Produce
2	$50K - $70K	Bremerton	WA	USofA	Food	Snack Foods
3	$30K - $50K	Portland	OR	USofA	Food	Snacks
4	$130K - $150K	Beverly Hills	CA	USofA	Drink	Beverages

	Category	Units_Sold	Revenue
0	Snack Foods	5	27.38
1	Vegetables	5	14.90
2	Snack Foods	3	5.52
3	Candy	4	4.44
4	Carbonated Beverages	4	14.00

c. *Identify the three countries in the data for the cateogrical variable Country.*

Finding unique values for Country. Countries include USofA, Mexico, and Canada

[ ]:
```
supermarket['Country'].unique()
```

[ ]:
```
array(['USofA', 'Mexico', 'Canada'], dtype=object)
```

d. *Sales took place in three countries. Convert the categorical variable Country to dummy variables for later numerical processing. What country gets dropped in the conversion?*

Use pd.get_dummies to create dummy variables for Country. Canada gets dropped because it is alphabetically first.

[ ]:
```
supermarket = pd.get_dummies(supermarket, columns=['Country'], drop_first=True)
supermarket.head()
```

[ ]:

	Transaction	Purchase	Customer	Gender	Marital	Homeowner	Children	\
0	1	2015-12-17	7223	F	S	Y	2	
1	2	2015-12-19	7841	M	M	Y	5	
2	3	2015-12-20	8374	F	M	N	2	
3	4	2015-12-20	9619	M	M	Y	3	
4	5	2015-12-21	1900	F	S	Y	3	

	Income	City	State	Family	Dept	\
0	$30K - $50K	Los Angeles	CA	Food	Snack Foods	
1	$70K - $90K	Los Angeles	CA	Food	Produce	
2	$50K - $70K	Bremerton	WA	Food	Snack Foods	
3	$30K - $50K	Portland	OR	Food	Snacks	
4	$130K - $150K	Beverly Hills	CA	Drink	Beverages	

	Category	Units_Sold	Revenue	Country_Mexico	Country_USofA
0	Snack Foods	5	27.38	0	1
1	Vegetables	5	14.90	0	1
2	Snack Foods	3	5.52	0	1
3	Candy	4	4.44	0	1
4	Carbonated Beverages	4	14.00	0	1

0.4 3. Missing Data

Data: http://web.pdx.edu/~gerbing/data/employee.xlsx

Read in the data

[ ]:
```
emp = pd.read_excel('http://web.pdx.edu/~gerbing/data/employee.xlsx')
emp.head()
```

[ ]:

	Name	Years	Gender	Dept	Salary	JobSat	Plan	Pre	Post
0	Ritchie, Darnell	7.0	M	ADMN	53788.26	med	1	82	92
1	Wu, James	NaN	M	SALE	94494.58	low	1	62	74
2	Hoang, Binh	15.0	M	SALE	111074.86	low	3	96	97
3	Jones, Alissa	5.0	W	NaN	53772.58	NaN	1	65	62
4	Downs, Deborah	7.0	W	FINC	57139.90	high	2	90	86

a. How many examples (rows of data) are there in the data file?

View the shape of the data frame

[ ]:
```
emp.shape
```

[ ]:
```
(37, 9)
```

b. Display rows of data that include the row of data with the missing data.

[ ]:
```
emp[emp.isna().any(axis='columns')]
```

[ ]:

	Name	Years	Gender	Dept	Salary	JobSat	Plan	Pre	Post
1	Wu, James	NaN	M	SALE	94494.58	low	1	62	74
3	Jones, Alissa	5.0	W	NaN	53772.58	NaN	1	65	62
30	Korhalkar, Jessica	2.0	W	ACCT	72502.50	NaN	2	74	87

c. Impute the median for the missing data of Years employed at the company. (Verify, as always.)

Isolate the variable 'Years'

[ ]:
```
X = emp.filter(['Years'])
X.head()
```

[ ]:

	Years
0	7.0
1	NaN
2	15.0
3	5.0
4	7.0

Import SimpleImputer and create instance

[ ]:
```
from sklearn.impute import SimpleImputer
imp_med = SimpleImputer(missing_values=np.nan, strategy='median')
```

Fit to isolated variable and execute transformation

[ ]:
```
imp_med = imp_med.fit(X)
X = imp_med.transform(X)
```

Update data frame with missing values and verify result

[ ]:
```
emp['Years'] = X
emp.head()
```

[ ]:

	Name	Years	Gender	Dept	Salary	JobSat	Plan	Pre	Post
0	Ritchie, Darnell	7.0	M	ADMN	53788.26	med	1	82	92
1	Wu, James	9.0	M	SALE	94494.58	low	1	62	74
2	Hoang, Binh	15.0	M	SALE	111074.86	low	3	96	97
3	Jones, Alissa	5.0	W	NaN	53772.58	NaN	1	65	62
4	Downs, Deborah	7.0	W	FINC	57139.90	high	2	90	86

d. Display rows of data that include the row of data with the imputed data to verify that the missing data has been properly imputed to show the change from missing to the imputed median for each variable.

Display updated row for James Wu by targeting iloc

[ ]:
```
emp.iloc[1]
```

[ ]:
```
Name      Wu, James
Years           9.0
```

```
Gender            M
Dept           SALE
Salary     94494.58
JobSat          low
Plan              1
Pre              62
Post             74
Name: 1, dtype: object
```

View multiple rows that includes the updated value

[ ]:
```
emp.head()
```

[ ]:

	Name	Years	Gender	Dept	Salary	JobSat	Plan	Pre	Post
0	Ritchie, Darnell	7.0	M	ADMN	53788.26	med	1	82	92
1	Wu, James	9.0	M	SALE	94494.58	low	1	62	74
2	Hoang, Binh	15.0	M	SALE	111074.86	low	3	96	97
3	Jones, Alissa	5.0	W	NaN	53772.58	NaN	1	65	62
4	Downs, Deborah	7.0	W	FINC	57139.90	high	2	90	86